



The NASA Human Exploration Rover Challenge

Combining Student Engineering Innovation, Real-World Solar System Exploration

The American space program has introduced a new student engineering design challenge—the NASA Human Exploration Rover Challenge—which revolves around NASA's plans to explore planets, moons and asteroids across the solar system in coming decades. The first rover challenge is set for April 11-12, 2014, at the U.S. Space & Rocket Center in Huntsville, Ala. Nearly 90 student teams will demonstrate the kind of practical engineering skills and innovation that sustain NASA's mission of exploration and discovery.

The event challenges high school, college and university students to design, construct, test and race mobility devices—lightweight, human-powered rovers—capable of performing in the varied, demanding environments to be explored by future voyagers. The challenge addresses engineering problems similar to those faced by NASA engineers preparing for a variety of solar system exploration missions. It is designed to teach students to troubleshoot and solve problems, and demonstrates NASA's continuing commitment to inspiring new generations of scientists, engineers, technicians and astronauts.

Teams registered to compete in the 2014 race include students from 19 states and Puerto Rico; and international challengers representing Germany, India, Mexico and Russia.

Scheduled around a typical school year, the project begins during the fall term, as teams organize, solicit sponsors, design their racing machines and begin construction. Each team may include up to six students and a teacher/mentor. High school students square off in one division; college and university teams compete in another.

Their challenge is to deliver a two-person, human-powered rover and to achieve the fastest vehicle assembly and race times, while avoiding penalties on a grueling course. This year's course is slightly more than half a mile of rock, gravel, sand and other materials which simulate the craters, ridges and other formations found on the harsh surface of various worlds other than our own. Top prizes are awarded to the three teams in each division that finish fastest, with the fewest penalties.

The rover challenge builds on the 20-year legacy of the NASA Great Moonbuggy Race. Six college teams participated in the first race, held in 1994 to commemorate the 25th anniversary of the Apollo 11 lunar landing. The race was expanded in 1996 to include high school teams. More than 80 teams fielded rovers of their own design during the final race in 2013.

NASAfacts



The NASA Human Exploration Rover Challenge is organized by the Academic Affairs Office at NASA's Marshall Space Flight Center in Huntsville. It is sponsored by the Human Exploration and Operations Mission Directorate at NASA Headquarters in Washington. The U.S. Space & Rocket Center, official visitor center of NASA's Marshall Center, will host the race.

Major corporate sponsors for the race are Lockheed Martin Corporation, The Boeing Co., Jacobs Engineering ESSSA Group, Aerojet Rocketdyne and Northrup Grumman Corp., all with operations in Huntsville. Other corporate and institutional contributors include Science Applications International Corporation (SAIC) of Huntsville; ATK Aerospace Systems of Salt Lake City, Utah; Davidson Technologies of Huntsville; the Universities Space Research Association (USRA), headquartered in Columbia, Md.; Teledyne Brown Engineering of Huntsville; the American Institute of Aeronautics and Astronautics (AIAA), headquartered in Reston, Va.; the Tennessee Valley Chapter of the National Defense Industrial Association (NDIA), headquartered in Arlington, Va.; Infotech Enterprises of East Hartford, Conn.; Corporate Office Properties Trust (COPT), headquartered in Columbia, Md.; the Tennessee Valley chapter of the International System Safety Society, headquartered in Unionville, Va.; and Booz-Allen Hamilton, AI Signal Research Inc., MSB Analytics, the National Space Club, the U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC), Redstone Federal Credit Union and Industrial Fabrication Co., all of Huntsville.

The NASA Human Exploration Rover Challenge is a flagship NASA education program implemented to inspire and engage America's next generation of scientists, technicians, engineers and mathematicians—the explorers who will carry on the nation's mission of discovery in the decades to come.

The rules

First-, second- and third-place winning teams in the high school and college divisions are selected based on the shortest total time to reconfigure their collapsed rovers and complete the obstacle course with a minimum of time penalties for various vehicle and course violations. Each team is permitted two runs of the course. The shortest total rover assembly and course completion time, plus penalties, comprises each team's final score.

Each vehicle must be solely human powered and propelled by two students—one female and one male—over the course. Every vehicle is required to have a specific set of accessories, which may be real or simulated. They include fenders or other dust abatement devices on each wheel, a high-gain antenna, a national or institution flag, two batteries, a video camera and an electronic control panel.

A critical element of the challenge—one that will be new to racers familiar with the Great Moonbuggy Race—is the wheel technology requirement. Teams must construct their own wheels. No inflatable or pneumatic tires are allowed on competing rovers. In addition to building sturdy vehicles, teams must innovate when it comes to their wheels, fashioning hardware that can navigate over large obstacles, provide traction and support on soft surfaces and cross cracks, crevasses and ruts similar to those found on the surfaces of other solar system bodies.

Innovation and creativity are the goal of the competition, but teams still must build to a number of NASA specs: minimum undercarriage height is 15 inches above the ground; the vehicle must demonstrate a turning radius of 15 feet or less; and maximum rover width must be no greater than 5 feet. There are no restrictions on vehicle length or height.

To reach the starting line, teams first must demonstrate that their folded or collapsed rovers will fit into a 5-foot-by-5-foot-by-5-foot cubic container, reflecting typical transport conditions for real rovers being transported by spacecraft to destinations across the solar system. Folded or collapsed rovers next are lifted by the two drivers and carried 20 feet without touching the ground, demonstrating lightweight portability. The rovers then are timed during assembly, readied for the course by the drivers and evaluated for safety by the judges.

Rovers race against the clock, rather than side-by-side. Judges mark their progress, assessing time penalties if the drivers touch the ground, leave the course or lose required onboard equipment. Drivers having extreme difficulty on the course are subject to removal. Struggling racers receive a time warning at 6 minutes and may be removed at the 8-minute mark if no further progress can be made. Racers continuing to make forward progress will be permitted to continue, however—up to the official 10-minute course time limit.

Nearly 400 volunteers from the Marshall Center and sponsor organizations will assist with the challenge, maintaining safety at numerous busy spots on the race course and serving as timekeepers, vehicle inspectors, obstacle judges and crossing guards.

Registered 2014 high school teams

Academia Menonita Summit Hills, San Juan, Puerto Rico
 Academy of Arts, Careers & Technology, Reno, Nev.
 Academy of Engineering & Green Technology,
 Hartford, Conn.
 Arab High School, Arab, Ala.
 Broad Run High & C.S. Monroe Technology School,
 Ashburn, Va.
 CBC High School Academy, Pasco, Wash.
 Central Magnet School (two teams), Murfreesboro, Tenn.
 Cullman Area Career Center, Cullman, Ala.
 East Central High School (two teams), Moss Point, Miss.
 East Limestone High School, Athens, Ala.
 Escambia High School, Pensacola, Fla.
 Fairhope High School (two teams), Fairhope, Ala.
 Florence High School, Florence, Ala.
 Franklin County High School, Winchester, Tenn.
 Greenfield Central High School (two teams), Greenfield,
 Ind.
 Howell Cheney Technical High School, Manchester, Conn.
 Huntsville Center for Technology, Huntsville, Ala.
 International Space Education Institute, Moscow, Russia
 Lima Senior High School (two teams), Lima, Ohio
 Mayfield High School, Las Cruces, N.M.
 Middle Tennessee State University (two teams),
 Murfreesboro, Tenn.
 Mount Juliet High School, Mount Juliet, Tenn.
 Parish Episcopal School, Dallas, Texas
 Pana High School, Pana, Ill.
 Pelham High School (two teams), Pelham, Ala.
 Petra Mercado Bougart, Humacao, Puerto Rico
 Rio Grande Preparatory Institute, Las Cruces, N.M.
 Riverside Christian Academy, Fayetteville, Tenn.
 Scotlandville Magnet High School, Baton Rouge, La.
 Teodoro Aguilar Mora Vocational High School (two teams),
 Yabucoa, Puerto Rico
 Tullahoma High School, Tullahoma, Tenn.
 University Gardens High School, San Juan, Puerto Rico
 Virginia City High School, Virginia City, Nev.

Registered 2014 college/university teams

Auburn University (two teams), Auburn, Ala.
 Belvill State Community College (two teams),
 Sumiton, Ala.
 Birmingham-Southern College, Birmingham, Ala.
 Cameron University (two teams), Lawton, Okla.
 Central Connecticut State University (two teams),
 New Britain, Conn.
 IILM Academy of Higher Learning, Greater Noida, India
 Christian Brothers University, Memphis, Tenn.
 Galgotias College of Engineering & Technology, Greater
 Noida, India
 Instituto Tecnológico de Veracruz, Veracruz, Mexico
 International Space Education Institute, Leipzig, Germany
 J.F. Drake State Technical College (two teams),
 Huntsville, Ala.
 North Dakota State University, Fargo, N.D.
 PEC University of Technology, Chandigarh, India
 Pittsburg State University (two teams), Pittsburg, Kan.
 Purdue University, West Lafayette, Ind.
 Purdue University Calumet (two teams), Hammond, Ind.
 Rhode Island School of Design, Providence, R.I.
 Rhodes College (two teams), Memphis, Tenn.
 Southern Illinois University Carbondale (two teams),
 Carbondale, Ill.
 SVKM-Narsee Monjee Institute-Mukesh Patel School
 of Tech. Mgt. & Eng., Mumbai, India
 Southwestern Oklahoma State University (two teams),
 Weatherford, Okla.
 Tecnológico de Monterrey Cuernavaca (two teams),
 Xochitpec, Mexico
 Tennessee Technological University (two teams),
 Cookeville, Tenn.
 Ohio State University (two teams), Columbus, Ohio
 Trine University, Angola, Ind.
 Universidad Politécnica de Chihuahua, Chihuahua, Mexico
 University of Alabama, Tuscaloosa, Ala.
 University of Alabama in Huntsville (two teams),
 Huntsville, Ala.
 University of Puerto Rico at Humacao (two teams),
 Humacao, Puerto Rico
 University of Puerto Rico at Mayaguez, Mayaguez,
 Puerto Rico
 University of Wyoming, Laramie, Wyoming

The course

The course takes the maintenance and grounds crew at the U.S. Space & Rocket Center about two weeks to prepare. It covers about seven-tenths of one mile of cement patios and pathways that wind around the exterior of the popular Huntsville space museum and NASA Visitor Center, twining through an atmospheric backdrop of famous American rockets and space vehicles.

The course includes 15 unique obstacles built from wood, aluminum, rubber tires, approximately 20 tons of gravel and 5 tons of sand. The material is carefully shaped to resemble craters, basins, boulders, ancient lava flows, crevasses and other obstacles common to various solar system destinations.

The unearthly landscape of the course is based on the original NASA Great Moonbuggy Race course at the Space & Rocket Center. It was designed in 1996 by Dr. Larry Taylor, a lunar geologist and professor at the University of Tennessee at Knoxville; Dr. J.M. Wersinger, a physics professor at Auburn University in Auburn, Ala.; and Dr. Frank Six, now the Marshall Center's university affairs officer.

Safety is paramount on the challenging course. Every driver is required to wear a seatbelt, helmet and gloves during the race, and more than 175 hay bales line the drive path to protect speeding drivers and spectators alike.

Course map

- **Obstacle 1: Asteroid Impact**—A field of simulated asteroid debris, with loosely packed, 3-inch to 12-inch fragments.
- **Obstacle 2: Wrinkle Ridges**—Ridges simulating how crusts of moons contract as underlying material cools and shrinks.
- **Obstacle 3: Crater with Ejecta**—A large crater, about 3 feet in diameter and 8 inches high, containing ejecta—the material thrown out of the crater on impact.
- **Obstacle 4: Rims of Craters**—Old, small craters partially covered by lava flows, each 2 feet in diameter and 3 inches to 6 inches high.
- **Obstacle 5: Lava Tubes**—Ridges produced when subterranean lava tubes collapse, leaving bumps in the surface material.
- **Obstacle 6: Cometary Debris**—A mix of impact craters and ejecta material expelled from impact sites.
- **Obstacle 7: Crevasses**—Surface ruts 1 inch to 4 inches wide and 4 inches to 6 inches deep, caused by cracks in the surface regolith or erosion by liquid/molten material.
- **Obstacle 8: Steep Incline**—A smooth surface simulating a lava/rock outcropping, with a 20-degree angle of elevation perpendicular to the rover's path of travel.
- **Obstacle 9: Lava Flow with Craters**—A simulated lava flow and crater with 15-inch clearance, strewn with boulders to require a 360-degree turn by rovers.
- **Obstacle 10: Tilted Craters**—An ascending, 15-degree slope, leading to a crater-pocked descent.
- **Obstacle 11: Erosion Bed**—A simulated stream bed of small, rounded pebbles, deposited to a depth of about 6 inches.

The repairs tents

NASA “pit crews” support student racers throughout the competition, welding, repairing and replacing damaged or faulty parts. The repairs tents include work tables and benches, equipment and material supplies for crews working on up to eight rovers at a time.

Team members make their own repairs, with oversight and guidance provided by Marshall engineers and technicians. All pit crew members are required to wear safety glasses in the work area, and all repair operations are supervised and assisted by trained professionals.

Repair tent equipment, provided by the Metals Engineering Division of Marshall’s Engineering Directorate, includes a variety of welding machines, hand tools, machining equipment, duct tape and epoxy—and a sizeable pile of salvaged scrap metal to replace or strengthen damaged rover parts.

The prizes

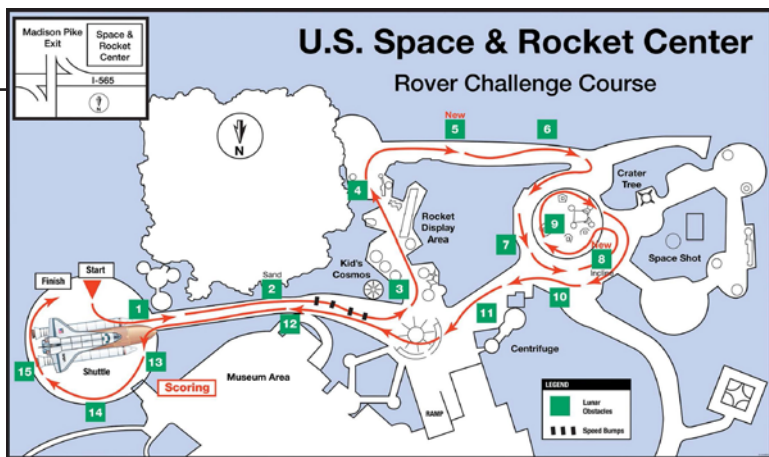
Top prizes are awarded to the three teams in the high school division and three in the college division that post the shortest official times, which factor in pre- and post-race inspection results, assembly and course times, obstacle faults and any other assessed penalties.

Additional awards include:

The **Technology Challenge Award**, presented by Jacobs ESSSA, includes a \$1,000 cash award for one winning team in the high school or college/university division which best addresses this year’s unique challenge: “Wheel Design & Fabrication.” Student teams must apply their engineering skills to develop innovative wheels to aid their navigation over the race course. Each design should take into account safety, adaptability to different surfaces, durability and strength, traction, flotation, overall performance and other factors. (Each year, a new mobility component technology will be the subject of investigation and testing in competition.)

The **AIAA Telemetry/Electronics Award**, presented by AIAA, includes a trophy and \$250 cash award for one high school team and one college/university team which develops the most innovative and useful real-time telemetry systems for operation during their course runs.

The **Best Report Award**, also presented by AIAA, will award one high school team and one college/university team a \$500 cash award for the best overall report detailing their rover-building experience. Winning reports will include detailed logs of the rover construction schedule, processes, budget, setbacks, technical challenges and resolutions, plus biographical material about all team members and their advisor.



- **Obstacle 12: Collapsed Fault**—Uneven ridges and depressions in the surface regolith, caused by shifts in underlying materials.
- **Obstacle 13: Loose Regolith**—Fine-grain sand 6 inches to 8 inches deep simulates the result of high-speed meteoroid impacts on the surface.
- **Obstacle 14: Hummocky Area**—Uneven terrain characterized by rocky hummocks on alternating sides of the travel path.
- **Obstacle 15: Undulating Terrain**—A gently uneven, ascending and descending surface with elevations ranging from 6 inches to 12 inches high.

The **Featherweight Award**, presented by NASA, is a trophy and \$250 cash award for the high school and college/university teams deemed to have best addressed the ongoing space exploration challenge of weight management. Judges will assess innovative approaches to safely minimize rover weight and will award the prize to the lightest-weight rovers in each division which finish a total run time—including assembly time and penalties—in 8 minutes or less.

The **Jesco von Puttkamer International Team Award**, presented by the Jesco von Puttkamer Society, includes a trophy and \$500 cash award for the fastest team from outside the United States in each division. The award honors von Puttkamer, the late, German-born NASA engineer who worked at Marshall from 1962-1974, supporting the Apollo moon missions, Skylab and Space Shuttle Programs. Von Puttkamer was instrumental in bringing international competitors to the NASA Great Moonbuggy Race beginning in the early 2000s.

The **Systems Safety Award**, presented by the Tennessee Valley Chapter of the International Systems Safety Society, includes a trophy for the team in each division judged to best exemplify system safety practices—the application of engineering and management principles, criteria and techniques intended to optimize safety.

The **Neil Armstrong Best Design Award** will be awarded by the AIAA to the team in each division whose rover design represents the best technical approach toward solving the engineering problem of navigating the extraterrestrial terrain. The award is based on the winning teams' technical approach to their designs, not on rover performance. It is named for Apollo 11 astronaut Neil Armstrong, who became the first American to set foot on the moon during that historic 1969 mission. Armstrong passed away in 2012.

For complete race rules and other official information, visit:

<http://www.nasa.gov/roverchallenge>

For information about other NASA education programs, visit:

<http://education.nasa.gov>

National Aeronautics and Space Administration

George C. Marshall Space Flight Center

Huntsville, AL 35812

www.nasa.gov/marshall

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